PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

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ENHANCING CARBON SEQUESTRATION AND RECLAMATION OF DEGRADED LANDS WITH FOSSIL-FUEL COMBUSTION BY-PRODUCTS

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Background

The concentration of CO_2 in the atmospheric has increased about 30% during the past 200 years. The increase, which is expected to continue throughout the foreseeable future, is largely driven by fossil fuel combustion; although, prior to 1940, human land use activities and land use changes made a significant contribution. The CO_2 rise and concomitant climatic changes might be slowed if CO_2 could be transferred from the atmosphere to terrestrial ecosystems and stored there for significant periods. Long-term storage of atmospheric carbon (C) in terrestrial ecosystems (terrestrial C sequestration) can potentially be achieved by enhancing natural biological processes that assimilate CO_2 (photosynthesis) and add the assimilated C to long-lived plant tissues, such as wood, and soil organic matter. Thus, to slow the increase in atmospheric CO_2 and other greenhouse gases and thereby minimize their potential environmental and economic consequences, a program of C sequestration may be required.

Reclamation of degraded and disturbed lands, such as mine spoil materials, highway rights-of-way, and poorly managed lands, through the addition of beneficiating amendments has a long history of research, but there are new factors to consider, since the need for C sequestration may change the economics. In the U.S., approximately 1% of the surface area consists of mined lands or highway rights-of-way. Poorly managed lands account for another 15%. Over the next 50 years, an increase of 1 wt% in stored-C content on these lands could remove on the order of 12 billion tons of C, a significant fraction of the total needed to stabilize atmospheric CO_2 levels.

Degraded lands are often characterized by acidic pH, low levels of key nutrients, compaction, poor soil structure, and limited moisture retention capacity. Addition of energy-related by-products can address these adverse conditions. The potential of energy by-products as soil amendments to enhance C sequestration in degraded lands can be most fully realized if these inorganic by-products are applied in conjunction with organic amendments, including mulch from biomass production and process wastes,

Primary Project Goal

The overall goal is to study the use of fossil fuel by-products to foster carbon sequestration in degraded lands. This has the triple benefits of carbon storage, by-product utilization, and land reclamation.

such as biosolids and pulp and sludge from paper production. These organic amendments can complement and extend the benefits of fly ash and other inorganic by-products. Thus, the addition of a suite of amendments containing both organic and inorganic by-products offers great potential for improving degraded land, increasing the sequestration of C, and utilizing energy by-products.

Conventional techniques for measuring carbon content in soil may not be cost-effective for sequestration projects. Thus, the soil carbon analysis of the numerous samples that may be required to characterize changes in soil carbon for sequestration projects could be very expensive. This project is examining the use of a laser spectroscopic technique for carbon and nitrogen analysis. Its real-time monitoring capabilities, high degree of analytical sensitivity and selectivity, and potential use in the field make it a good candidate.

Objectives

- To examine the terrestrial carbon sequestration potential of lands that have been disturbed by mining, highway construction, or poor management practices.
- To identify the sequestration-enhancing effects of land amendment by a combination of solid by-products from fossil-fuel combustion and biological wastes from treatment facilities.
- To identify optimal selection and delivery strategies to maximize the contribution of amendments to carbon sequestration.
- To evaluate existing experimental sites, conduct laboratory experiments to identify key amendment types and potential management strategies, and design field experiments to test and demonstrate carbon sequestration.
- To foster interaction between the scientific and user communities to maximize the application of the new knowledge generated by this project.

Accomplishments

Alkaline fly ash amendments have been identified as having a significant ability to enhance humification, the main process responsible for organic carbon sequestration in soils. The fly ash properties contributing to this effect are believed to include alkalinity, porosity, and the presence of unburned carbon, which acts as a hydrophobic sorbent for organic compounds. The laboratory results are consistent with field studies indicating that after 15 - 30 years lands amended with fly ash have higher levels of carbon in the soil and that amendment with biosolids does not produce a consistent benefit. Further study of the role of unburned carbon may allow productive use of alkaline fly ash from low-NOx burners that is currently relegated to landfills. Work will involve characterization of fly ash with respect to alkalinity, micro- and meso-porosity, and unburned carbon content and testing to determine efficacy in promoting humification. Tests involving soils with and without carbonate minerals will be performed to confirm the minimization of carbonate dissolution by the presence of unburned carbon. This work will complement studies of the same ashes at ORNL with respect to their potential for nitrous oxide emissions and leaching of metals. Current results indicate very low potential for leaching of metals and no toxicity of the leachates when measured using the Microtox technique. Also, mixing fly ash with biosolids alters leaching but the biosolids can act as a source of metals for leaching. Project results will be summarized in a set of optimum site-management practices and practical guidelines that include policy, stakeholder, and technical considerations.

Soil sampling pit showing development of soil over coal refuse.

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PARTNERS

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COST

Total Project Value
$1,152,000

DOE/Non-DOE Share
$1,152,000/$0

Benefits

This project has the potential for triple benefits. First, by increasing the carbon content of soils, it will decrease the net emission of CO_2 to the atmosphere. Second, it provides a beneficial use of waste products that currently must be landfilled at a cost. Third, marginal lands are brought back into productive use as forests, pastures, agricultural lands or recreational areas.